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Does the presence of a human affect the preference of enrichment items in young, isolated pigs?

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ABSTRACT

Pigs may be housed individually in both production and research settings. Gregarious by nature, pigs kept in isolation may show behavioural and physiological signs of stress. In this study we investigated the preference of individually housed pigs, for social and non-social enrichments. Three enrichment items were compared: a mat (MAT), a companion (COM) and a mirror (MIR). Fourteen weaner pigs (Yorkshire × Landrace) were housed individually with continuous access to 4 adjacent pens. One pen was a control (CTRL) and had no enrichment; the others had one enrichment each, either a mat on part of the woven wire floor (MAT), a companion visible across the passageway (COM) or a mirror on one wall (MIR). Pigs spent more proportion of time ($P = 0.021$) in the COM pen (0.65 ± 0.07) compared to the CTRL pen (0.31 ± 0.07) with the MAT pen (0.57 ± 0.07) and the MIR (0.42 ± 0.07) pen as intermediates. They also spent more total time engaged in investigative and inactive behaviours in the COM pen compared to the CTRL pen ($P = 0.007$). A second analysis was performed to investigate changes in preferences in the presence or absence of a human in the room. The pens were then combined into two categories: social pens (COM and MIR) and nonsocial pens (MAT and CTRL). The probability of a pig being observed in the MIR pen when a human was present was significantly higher ($P = 0.0001$), than when absent. Within the social enrichments, the probability of the animal being observed in either MIR or COM pen was not different ($P = 0.017$). Our results confirm that preference studies may be highly sensitive to experimental conditions. Thus, the assumption that the most important preference is the one the animal spends most of its time with can be misleading. It appears that a mirror may be used by the animal for social support during periods of perceived threat, however further investigation is warranted.

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1. Introduction

The vast majority of animals used in laboratory settings continue to be rodents. In the UK, which has the most comprehensive animal reporting statistics, just over 80% of all animals used in experimental procedures are rodents, with 90% of this total being mice (Home Office, 2011). The use of rodents as models for humans and their applicability continues to be debated (Olson et al., 2000) and, as an alternative, pigs are gaining popularity for use as models in many areas of biomedical research (Schook et al., 2005). This increase in use is mainly driven by the fact that pigs have many similar physiological and anatomical features to humans such as their skin, digestive and cardiovascular systems (Bollen et al., 2010). However there is also societal

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pressure to reduce the number of primates and companion animals, such as dogs, used in research, although the ethical "acceptability" of pigs as experimental animals continues to be debated (Webster et al., 2010).

Within research and laboratory settings, pigs are often housed in isolation and in barren environments. These housing conditions are generally designed for optimal control over the environment and a perceived, though disputed (Richter et al., 2009), need for environmental standardization necessary to safeguard reproducibility (Beynen et al., 2003). Although pigs are endorsed as readily adaptable to a variety of systems (Kyriazakis and Whittemore, 2006) these statements pertain to the health and productivity of pigs in a commercial farming setting, and do not take pig behaviour and welfare into account.

Social isolation of gregarious animals is capable of inducing high levels of stress (Boissy and Le Neindre, 1997; Piller et al., 1999; Spani et al., 2003). Placing a socially evolved animal into isolation eliminates their ability to benefit from communal living advantages, which in nature would include defence against predators, improved foraging, information exchange, pathogen resistance to or after exposure, and pooling of resources (Burger and Gochfeld, 2001; Mendl and Held, 2001; Ward and Zahavi, 1973). Despite the fact that their need for these social strategies is practically eliminated in captivity, social animals still become stressed by isolation (Andersen et al., 2006). For example, young pigs especially show behavioural and physiological signs of stress when housed in isolation such as increased cortisol production (Ruis et al., 2001; Stolba and Wood-Gush, 1989), decreased body temperature (Ruis et al., 2001), decreased Tumour Necrosis Factor-alpha (TNF-α) (Tuchscherer et al., 2004), and increased frequency of behaviours associated with anxiety and stress (Herskin and Jensen, 2000; Tuchscherer et al., 2006). Similarly, housing within barren environments may also modify pigs' behaviour and physiology. For example, in commercial settings, barren environments have been shown to elicit increased aggression (O'Connell and Beattie, 1999), decreased behavioural diversity (Haskell and Hutson, 1996), increased adrenal weights (Beattie et al., 2000) and lower growth rates (Lyons et al., 1995).

A common buffer for the stress caused by isolation and barren housing is the implementation of environmental enrichment. Environmental enrichment involves the enhancement of an animal's physical or social environment and may be defined as "an improvement in the biological functioning of captive animals resulting from modifications to their environment" (Newberry, 1995). Environmental enrichment is increasingly viewed as an essential research component (Guide for the Care and Use of Agriculture Animals in Research and Teaching, 2010), but the forms that the enrichment may take will be constrained by the setting in which the animal is being kept – i.e. within a zoo, a laboratory or on a farm. For pigs, the majority of enrichment studies have been carried out on farm settings, where characteristics such as ingestible and destructible become important over time (Van de Weerd et al., 2003) and the provision of straw is seen as having high potential in effectiveness (Van de Weerd and Day, 2009). For laboratory pigs it is critical that the enrichments should positively enhance the pig's biological functioning, yet be practical to employ within a laboratory setting. Laboratory housing for swine presents difficult challenges due to the need of a sterile and clean environment. Additionally, nutritional studies often closely monitor feed intake and providing ingestible material may compromise the results (Dean, 1999). For these reasons, it will be beneficial to develop enrichments targeted to areas of the laboratory environment that may be possibly stressful to the pigs. Consequently, ingestible and destructible enrichment items could not be considered for this study. Unfortunately, little quality research has been done on the enrichment benefits and preferences in laboratory housed swine (Bollen et al., 2010).

For these reasons, our experimental enrichments focused on two items that we expected to be important for a pig housed individually in a laboratory type environment; namely companionship and comfort. Firstly, knowing that pigs are highly social and that isolation is stressful, we offered the pigs access to sight and relative proximity to another pig. We also investigated whether provision of a mirror could simulate the presence of a conspecific. Secondly, knowing that pigs in indoor housing systems spend the vast majority (over 75%) of their time inactive (Broom et al., 1995), we offered the pigs access to a rubber mat that may offer a more comfortable lying surface than perforated metal (Tuyttens et al., 2008) and confer skin lesion score benefits (Elmore et al., 2010). In order to test the relative importance of these enrichments, we used a preference test in which the pigs could choose to spend time with only one resource.

Preference tests have been used historically as a method of analysing an animal's preferred option, including enrichment objects. However, preference tests are often criticized for their results being highly specific to the particular conditions in which the test is carried out (Dawkins, 1982; Duncan, 1978; Hughes, 1976; Kirkden and Pajor, 2006). The presence of a human in the room can affect behaviour and physiology of rats (Cloutier and Newberry, 2010) and it has been shown that a pig's fear of humans can influence its welfare and productivity (Rushen et al., 1999). Human presence could also influence the pig's preference. Our objectives therefore were to determine the preference of individually housed pigs for different enrichment items comprising a mat, a conspecific companion, or a mirror and whether these preferences are influenced by human presence.

2. Materials and methods

All procedures in this experiment were approved by Purdue Animal Care and Use Committee prior to conducting the experiment (PACUC approval 09-055). The experiment took place during the months of March, April, and May of 2010. The animals used in this study were returned to Purdue University swine herd at the end of the experiment.

2.1. Animals, housing and management

Sixteen, male Yorkshire $\times$ Landrace weaner pigs (mean $\pm$ SE, 22.7 ± 2 kg in weight) were used as test subjects. The pigs were selected from the farm population based on similar weights and prior to the experiment were housed in groups in flat-deck weaner pens (1.4 m × 1.4 m in dimension), with perforated metal floors and ad libitum access to water and standard swine nursery phase 4 diet from a feed hopper. Four animals were tested per replicate, over four replicates but two animals were removed from the study due to a missing data caused by malfunction of the video equipment ($N = 14$). Within each replicate, the four pigs were selected so that one pair consisted of pen-mates and the other pair consisted of pigs from different weaner pens. No littermates were selected as pairs.

At testing, each pair of pigs was moved to one of two similar, thermally controlled rooms (maintained at 23 °C) at the Animal Sciences Research and Education Center Swine Unit of Purdue University. One pig per pair was housed with continual access to a row of four adjacent pens (2.03 m × 1.17 m), three of which included one enrichment item per pen – a mat (MAT), a companion visible across a 0.8 m wide passageway (COM) and a mirror on one wall (MIR) (1.17 m × 1.0 m) – and one pen acted as control (CTRL) with no enrichment (see Fig. 1). The other pig from each pair acted as the companion pig and was housed in a single pen (2.03 m × 1.17 m) across the passageway. After one week, the test and the companion pigs swapped places.

The preference pens were created by removing part of the metal pen dividers to connect four pens together. The partitions between the pens were 1.12 m long. Plywood was then attached to the existing metal pens using zip ties to block the test pig's vision of the room, except at the front of the COM pen where they were allowed visual contact of the companion across the passageway (see Fig. 1), thus the test animal was only able to access and view each enrichment item while in that enrichment's pen. Within each pen, pigs were given ad libitum access to a standard swine nursery phase 4 diet in a single-space feeder and water through wall attached nipple drinker. The floors were of perforated metal. In addition to natural light through large windows above the test pens, artificial light was kept on between 5:00 and 17:00 h. Air quality was controlled by a positive pressure ventilation with about 6–8 air changes/h.

The same human caretaker (blind to the human present/absent treatment), wearing boots, jeans, and light-coloured shirt, entered the pens every morning at 7:30 h for pen cleaning, testing drinkers for proper functioning, and checking and replacing feed from feeders, lasting approximately 30 min. The husbandry procedures were carried out in a standardized manner. The caretaker entered the room, calling out to the pigs so as not to startle them, turned on the hose by the door and began by spray-cleaning the choice pens, starting with the pen nearest the door and working down the row. Cleaning was done from the passageway, without getting into the pens. After cleaning the choice pens, the companion pig's pen was cleaned, again from the passageway. Next, the feeders were checked in all pens and replenished were necessary, from the passageway. Finally, the caretaker entered the choice pen nearest the door and walked down the row of pens checking drinker function, exiting the choice pen furthest from the door. The companion pig's drinker was then checked from the neighbouring pen, after which the caretaker exited the room. During the whole procedure, husbandry was carried out without any initiated interaction with the pigs. If a pig initiated interaction, the caretaker reciprocated neutrally, to avoid any positive or negative reinforcement.

Each pig was in the testing room for two weeks, one week as the test animal, and the other as the companion (not necessarily in that order). Whether the pig was housed in the companion pen first, KNOWN, or the test pen first, UNKNOWN was noted and added into the analysis. Additionally, whether the selected pigs from the same home

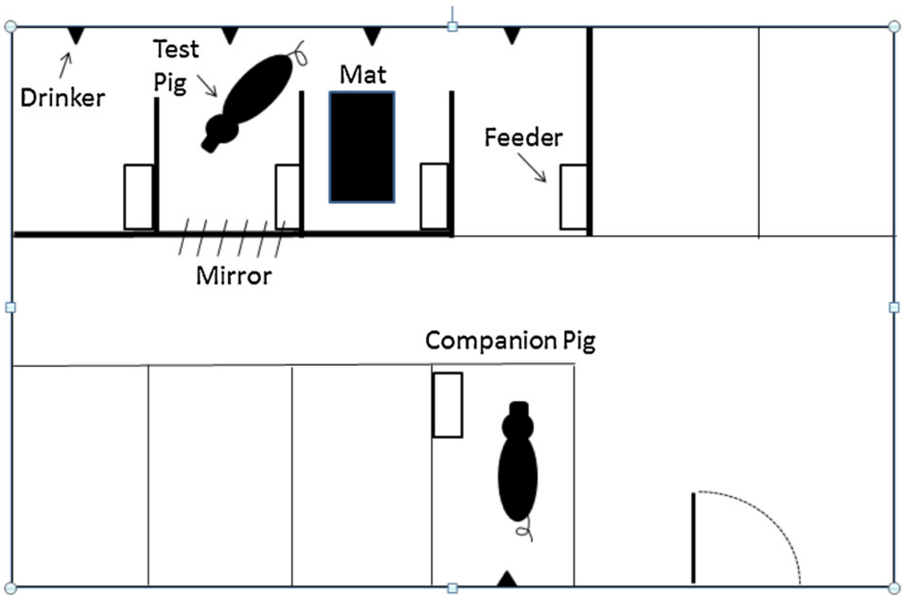

Fig. 1. Diagram of the experimental rooms.

pen (HP) or different pens, not home pen (NHP) was also taken into account. All experimental animals were naïve to the mat and mirror enrichment items. The spatial order of the preference pens were rotated with every new test pig, allowing for complete balance with the preference pen locations.

2.2. Behaviour recording

Pigs were video recorded 24 h a day. However, due to limited visibility during the night, video used for time budget information was from 5:00 to 19:00 h. Video was recorded in real-time mode using a digital video recorder (CV-S4DVRLX, Inter-Pacific Inc., Wheeling, IL, USA) and cameras (WV-CL 350, Panasonic Corporation, Osaka, Japan) with detachable lens (Computar TG4Z2813FCS-31, CBC Co. Ltd., Tokyo, Japan). Each camera was positioned to capture two of the four pens and was connected to the DVR. The video was analyzed by one experienced observer for time budget information by instantaneous scan sampling every 10 min. For each observation, four pen locations, 10 behaviours and four postures for the tested individual were recorded using the elements described in Table 1.

Since the time it took for the human to appear/disappear on camera when entering/leaving the room was less than 3 s, the data from when the human was present was collected when a human entered the view of any of the two cameras located inside the room and ended when the human left the sight of the camera view for the final time that morning, which was when they were finished with their husbandry chores. Anytime outside of these periods was labelled as human not present.

Table 1
Description of pen locations, behaviours, and postures used for behaviour analysis.

Pen location	Description
Mat (MAT)	The pig's head was within the MAT pen
Mirror (MIR)	The pig's head was within the MIR pen
Companion (COM)	The pig's head was within the COM pen
Control (CTL)	The pig's head was within the CTL pen
Behaviours	Description
Eat	Head in feeder
Drink	Mouth in contact with nipple drinker
Eliminate	Excretion of either urine or faeces
Walk	Feet were moving in a way that advanced the animal
Root floor	Snout was in contact with the woven wire floor
Pen interaction	Snout in contact with material comprising the pen
Alert	Head upright and ears erect
Nose mat	Snout in contact with mat
Nose mirror	Snout in contact with mirror
Inactive	No behaviours being performed
Postures	Description
Standing	Pig is supporting its body weight equally on all four legs
Lying sternally	Pig is lying up-right with chest touching the ground
Lying laterally	Pig is lying on side with shoulder touching the ground
Sitting	Front half of pig is upright, while hind quarters are touching the floor

2.3. Statistical analysis

"Pig", the experimental unit, was treated as a random effect in the analysis and nested within treatment. Significant results ($P < 0.05$) were further examined using post hoc Tukey tests to explore the relationship between the tested interactions.

Preliminary analysis included UNKNOWN and KNOWN as well as HP and NHP variables (whether if the pig was housed in the companion pen first, KNOWN, or the test pen first, UNKNOWN and were the selected pigs from the same pen (HP) or different pens (NHP)). However, these variables were found to be not significant ($P > 0.05$) and removed from the sub sequential models (listed below). Additionally, preliminary analyses included the fixed effects of replicate and day, but were removed from the final analysis due to a lack of significance ($P > 0.05$).

2.3.1. General location preference

Enrichment preference was analyzed as repeated measures mixed models (REML) in JMP for Windows (JMP 6.0, SAS Institute Inc., Cary, NC, USA). The experimental unit, "Pig", was treated as a random effect in the analysis and nested within treatment. Treatments included in the model included pen location. Observations were summed and then percentages of observations within treatment per pig were calculated. Percentages were logarithmically transformed to meet the assumptions of REML (homogeneity of variance, normality of error and linearity).

2.3.2. Effect of human

Changes in enrichment preferences when a human was present and absent were then analyzed by repeated measures logistic regression (PROC GLIMMIX) in SAS for Windows (SAS Institute Inc., Cary, NC, USA). Due to the smaller number of observations made while a human was present compared to absent, PROC GLIMMIX analysis was chosen because of its ability to fit models to multivariate data in which observations do not all have the same distribution. Treatment included pen location and presence/absence of a human. Also, because of the binomial requirements of the PROC GLIMMIX, enrichments were then grouped into either SOCIAL (MIR and COM) or NONSOCIAL (CTL and MAT) categories. Raw data were transformed in SAS using the LOGIT transformation function to allow for standard linear modelling. A first analysis was performed to determine if there was an increased probability of choosing a SOCIAL enrichment when a human is present compared to when absent. A second analysis was done to determine the probability of choosing the MIR over the COM when a human was both present and absent.

2.3.3. Overall pen differences in behaviour and posture

Overall behaviour and posture differences between treatments were analyzed as repeated measures mixed models (REML) in JMP. Treatments included in the model included pen location. Due to the disparity of behaviours chosen in the ethogram and the inability to perform those behaviours in all pens, behaviours were then categorized into inactive (inactive), investigate (root floor, nose mat, nose mirror, pen interaction and alert), maintenance (eat, drink and eliminate), and walk (walk) behaviours. Behaviour observations were logarithmically transformed to meet the assumptions of REML.

3. Results

3.1. General location preference

The enrichment item preference was significantly different only between COM and CTL pens. Pigs spent more time (REML: $F_{3,39} = 3.6$, $P < 0.05$, Fig. 2) in the COM pen compared to CTL with MAT and MIR as intermediates (Fig. 2).

3.2. Effect of human

The probability of a pig being observed in a social pen when a human was present was significantly higher (REML: $F_{1,13} = 29.9$, $P < 0.001$, Fig. 3), than when absent. Therefore, an analysis was performed to determine if within the social enrichments the pigs preferred the MIR or COM. It was found that the pigs were observed in the MIR and COM pens in equal proportions when the human was present. However, when the human was absent the pig was observed in the COM significantly more than when the human was present (REML: $F_{1,13} = 7.4$, $P < 0.05$, Fig. 4).

3.3. Overall pen differences in behaviour and posture

There were no overall differences in posture between locations (REML: $F_{9,117} = 1.9$, $P = 0.064$). However, the pig's location was found to affect its behaviour (REML: $F_{9,117} = 2.7$, $P < 0.001$). Pigs spent more time inactive ($P < 0.05$) within the COM (26.6% ± 2.4 of observations, raw data) and MAT (23.6% ± 2) pens compared to the CTRL (7.7% ± 2.4), with MIR as an intermediate (11.9% ± 2.4). Pigs spent more time engaging in investigative behaviours (Tukey: $P < 0.05$) within the COM pen (7.0% ± 2.4) compared

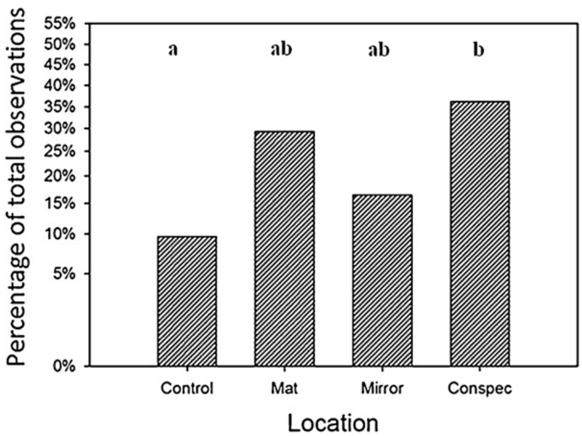

Fig. 2. Percentage (mean) of total observations spent in each pen by the test pig. Data are back transformed and from the presence and absence of a human combined. *Footnote:* Different letters (A and B) indicate differences in pairwise comparisons ($P < 0.05$). The analysis was performed using angular transformed data (in SAS) and the transformed results (LS mean ± SE) are as follows: control pen = 0.31 ± 0.07; mat pen = 0.57 ± 0.07; mirror pen = 0.42 ± 0.07; conspecific pen = 0.65 ± 0.07.

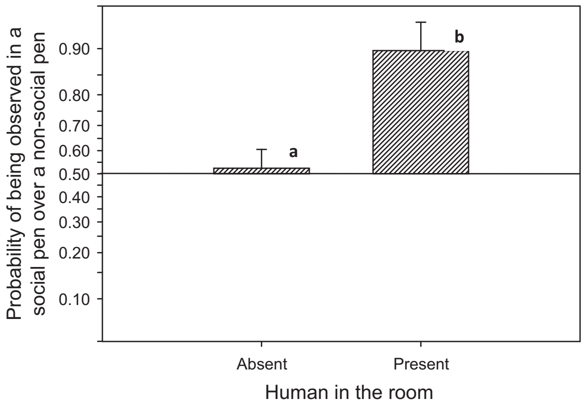

Fig. 3. The back transformed probability (mean) of a pig being observed in the social enrichment pens over the non-social enrichment pens, in the presence and absence of a human. *Footnote:* Different letters (a and b) indicate differences between present and absent conditions ($P < 0.001$). The analysis was performed using logit transformed data (in SAS) and the transformed results (LS mean ± SE) are as follows: human absent = 0.097 ± 0.3; human present = 2.2 ± 0.5.

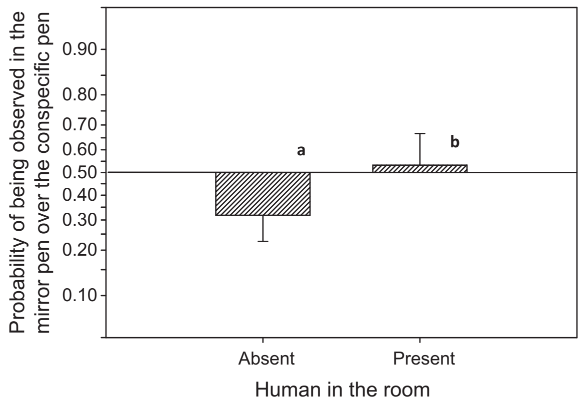

Fig. 4. The back transformed probability (mean) of a pig being observed in the MIR enrichment pen over the COM enrichment pen, in the presence and absence of a human. *Footnote:* Different letters (a and b) indicate differences between present and absent conditions ($P < 0.05$). The analysis was performed using logit transformed data (in SAS) and the transformed results (LS mean ± SE) are as follows: human absent = 0.76 ± 0.5; human present = −0.13 ± 0.6.

to the CTRL pen (1.4% ± 2.4), with MAT (4.7% ± 2.4) and MIR (2.5% ± 2.4,) pens as intermediates. Pigs were found to spend equal time between pens performing maintenance and walking behaviours (Tukey: $P > 0.05$).

4. Discussion

Our results showed that the environmental enrichment preference of pigs is largely dependent upon their environment. Pigs showed an overall propensity to spend their time with the COM enrichment. Only when a human was present were the MIR and the COM enrichment equally preferred. Possible factors that may be influencing this result include time of day when the human is present and the pigs' possible positive and negative associations with the human. In terms of time of day, pigs show circadian patterns in behaviour (Dantzer, 1973) and it is possible that pen choice was influenced by time of day. However, the data were examined with respect to morning, afternoon and evening and pigs were consistent over the day in where they spent their time. The pig location immediately before the human entered the room was also representative of the whole day means, being more often in the MAT and COM pens than the MIR and CTRL pens. Thus, the fact that the human was only present in the morning did not impact the results. In terms of the pigs' associations with the human, it has long been known that the way the human interacts with the pigs will impact the pigs' responses to the human (Gonyou et al., 1986). Our human was neutral or minimal in their interactions with the pigs in this study, only entering the pens when necessary to check drinker function. All other tasks were done from outside the pen. Feed was available ad libitum, so there was no positive association which may have caused the pig to move towards the human upon entry. Likewise, there was no imposed negative association, such as blood sampling or aversive handling which may have caused the pig to rapidly retreat from the human upon entry. Because the location of the choice pens was rotated, and thus differed for each pig, the MIR and COM pens were equally positioned closest to and farthest away from the human's point of entry into the room and the pens. Thus, due to the different enrichment uses when a human is present compared to when a human is absent, our results confirm that preference studies are indeed sensitive to experimental conditions and using time spent with an item as a measure of preference is not a reliable indicator of importance.

As mentioned in the introduction, it is not surprising that overall the pig values the companionship received in the COM pen over the remaining enrichment choices due to an innate need for communal living, plausibly because neither the MAT nor the MIR provides olfactory or vocal feedback to the tested animal. Social animals not only communicate with conspecifics to inform them of danger, but are shown to have a higher incidence of recovery from environmental stressors when housed within a group (Kikusui et al., 2006; Liddell et al., 2005; Seyfarth and Cheney, 2003). It was unexpectedly found that the MIR is also significantly important to the pig during times of perceived threat. Mirror usage has been tested in a number of different species including rodents, chimpanzees, elephants, rabbits, sheep, poultry and cattle. Broom et al. (2009), in the only peer reviewed article on mirror usage by pigs, demonstrated that pigs can use mirrors as tools for locating food. However, it is not known if pigs are self-aware, or if they are interpreting their reflection as a conspecific.

Many species, except for rodents, have a preference to be in the presence of a mirror over isolation (Parrott et al., 1988; Piller et al., 1999; Zotte et al., 2009), and seem to benefit from the supplementation of a mirror to their surroundings. For instance, the presence of a mirror resulted in an increase in exploratory pecking and decrease in vocalization in poultry chicks (Montevechhi and Noel, 1978). Isolated heifers exposed to a front-viewed mirror had decreased locomotor movement as well as reduced heart rate (Piller et al., 1999). Mirrors placed in stables have been shown to decrease stereotypic weaving in horses (Mills and Davenport, 2002). Unfortunately, the benefit of mirror usage in laboratory animals has been limited to a handful of experiments, and is only commonly implemented as an enrichment addition for non-human primates. In addition, it is not known how many other experiments testing preference for mirror (or other items for that matter) have mistakenly concluded a possibly benefiting enrichment to be "unpreferred" or "unimportant" by only testing it in specific environmental conditions. Therefore, mirror supplementation for naturally gregarious animals housed in isolation should be further investigated.

It was not possible to record when the pigs' eye was looking directly at the mirror or the companion. However, it is generally accepted that pigs have relatively poor vision with severe near-sightedness, utilizing olfactory cues as their primary sense (Hutson et al., 1993, Zonderland et al., 2008). The way the pig processes its surroundings through these senses is most certainly the key to understanding our observations. Stressed animals are highly motivated to be in the presence of conspecifics (Ishiwata et al., 2007) and one explanation is that of social support. Social support can be defined as the benefits brought about by social partners that enhance one's ability to cope with challenges (Rault, 2011). Although both the COM and MIR enrichments offer benefits of sociality, they also have their drawbacks. The companion animal provides both vocal and olfactory feedback to the test pig, however due to the alleyway separating them, the visual component is limited and the tactile component of social support is not accessible. The mirror provides opportunity for the pig to receive tactile stimulation by lying parallel to it, as well as visual feedback due to its close proximity within the pen. These results are consistent with research suggesting an additive effect of the combination of visual, auditory, tactile, olfactory and gustatory cues in swine during social recognition (Kristensen et al., 2001).

It is also important to mention that because the definition of environmental enrichment is vague and is often used inconsistently in the literature, it is more useful to look at its overall endpoints: to improve the biological functioning of the animal, such as reproductive success or improved health (Newberry, 1995) and allow the animal a perceived sense of control over its environment (Garner, 2005). Numerous studies have concluded that the ability of an animal to cope with its environment may be more important in achieving good welfare (Broom, 1991; Wechsler, 1995; Weiss, 1968). It is possible that in the current experiment, the animal was provided with the means to perform a behaviourally relevant reaction (locate social support) to a perceived threat (the presence of a human). This means that both the conspecific across the alleyway and the mirror are enrichments the pig is highly motivated to seek out when a human is present and which may provide social support, thereby helping them cope with environmental disturbances. The ability to control aspects of their environment is extremely important for laboratory animal welfare because an inability to cope with a below satisfactory environment is likely to result in reduced fitness (Broom, 1991).

In COM pens the pigs increased investigative and inactive behaviours and these results suggest that the pigs may be less anxious with a conspecific nearby, although physiological measures would be needed to confirm this effect. Pigs' investigative behaviours such as rooting and chewing are part of the animal's normal repertoire, thus increases in the occurrence of these behaviours are often seen in environments associated with low fear and anxiety (D'Eath and Turner, 2009; Piller et al., 1999).

Lying comfort is considered highly important to animal welfare (Tuyttens et al., 2008). This may be due to an improvement in the physical or thermal comfort of the animals. Sows have shown a preference for lying in areas covered with mats compared to concrete floors (Gravås, 1979; Tuyttens et al., 2008). Our results were not consistent with these findings because we found no difference in posture behaviour. However, our pigs spent significantly more time inactive in the MAT pen compared to the CTRL pen. It may be possible that differences may have been observed by combining the lying sternally and lying laterally observations and/or recording the postures during the nighttime hours. Both studies by Gravås (1979) and Tuyttens et al. (2008) were carried out over 24-h periods. There was an indication in our study that MAT use increased in the last third of the day. Infrared camera capability could have enhanced the study enabling sampling overnight.

This study did not address whether the enrichment items studied would be subject to habituation after prolonged exposure. It is unlikely however, that pigs would habituate to them since the enrichment items address such highly motivated and innate needs of the pig – communal living and comfort. In fact, a recent study (Tuyttens et al., 2008), found an increase in mat use over time, although these results may have been confounded with a change in stocking density and/or temperature between the two examined periods.

5. Conclusion

Overall, pigs showed a propensity to spend their time with the COM enrichment. Only when a human was present were the MIR and the COM enrichment equally preferred. Our results suggest that a mirror may be used by the animal for social support during periods of perceived threat, however further investigation is needed to determine whether a mirror would confer welfare benefits to pigs housed in isolation and whether habituation would occur over time.

Conflict of interest

None.

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References

Andersen, I.L., Nævdal, E., Bøe, K.E., Bakken, M., 2006. The significance of theories in behavioural ecology for solving problems in applied ethology – possibilities and limitations. Appl. Anim. Behav. Sci. 97, 85–104.

Beattie, V.E., O'Connell, N.E., Moss, B.W., 2000. Influence of environmental enrichment on the behaviour performance and meat quality of domestic pigs. Livest. Prod. Sci. 65, 71–79.

Beynen, A.C., Gärtner, K., van Zutphen, L.F.M., 2003. Standardization of animal experimentation. In: van Zutphen, L.F.M., Baumans, V., Beynen, A.C. (Eds.), Principles of Laboratory Animal Science. Elsevier, Amsterdam, pp. 103–110.

Boissy, A., Le Neindre, P., 1997. Behavioral, cardiac and cortisol responses to brief peer separation and reunion in cattle. Physiol. Behav. 61, 693–699.

Bollen, P.J.A., Hansen, A.K., Olsen Alstrup, A.K., 2010. The Laboratory Swine, 2nd ed. CRC Press LLC, Boca Raton, Florida.

Broom, D.M., 1991. Animal welfare: concepts and measurements. J. Anim. Sci. 69, 4167–4175.

Broom, D.M., Mendl, M.T., Zanella, A.J., 1995. A comparison of the welfare of sows in different housing systems. Anim. Sci. 61, 369–385.

Broom, D.M., Sena, H., Moynihan, K.L., 2009. Pigs learn what a mirror image represents and use it to obtain information. Anim. Behav. 78, 1037–1041.

Burger, J., Gochfeld, M., 2001. Smooth-billed ani (Crotophaga ani) predation on butterflies in Mato Grosso, Brazil: risk decreases with increased group size. Behav. Ecol. Sociobiol. 49, 482–492.

Cloutier, S., Newberry, R.C., 2010. Physiological and behavioural responses of laboratory rats housed at different tier levels and levels of visual contact with conspecifics and humans. Appl. Anim. Behav. Sci. 125, 69–79.

Dawkins, M.S., 1982. The elusive concept of preferred group size in domestic hens. Appl. Anim. Ethol. 8, 365–375.

Dantzer, R., 1973. Étude de la stabilisation des rhythmes d'activité locomotrice de porcelets introduits dans un nouvel environnement. J. Physiol. (Paris) 66, 495–503.

Dean, S.W., 1999. Environmental enrichment of laboratory animals used in regulatory toxicology studies. Lab. Anim. 33, 309–327.

D'Eath, R.B., Turner, S.P., 2009. The natural behaviour of the pig. In: Marchant-Forde, J. (Ed.), The Welfare of Pigs, Animal Welfare 7. Springer, Dordrecht, The Netherlands.

Duncan, I.J.H., 1978. The interpretation of preference tests in animal behaviour. Appl. Anim. Ethol. 4, 197–209.

Elmore, M.R.P., Garner, J.P., Johnson, A.K., Richert, B.T., Pajor, E.A., 2010. A flooring comparison: the impact of rubber mats on the health, behavior, and welfare of group-housed sows at breeding. Appl. Anim. Behav. Sci. 123, 7–15.

Garner, J.P., 2005. Stereotypies and other abnormal repetitive behaviors: potential impact on validity, reliability, and replicability of scientific outcomes. ILAR 46, 106–117.

Gravås, L., 1979. Behavioural and physical effects of flooring on piglets and sows. Appl. Anim. Ethol. 5, 333–345.

Gonyou, H.W., Hemsworth, P.H., Barnett, J.L., 1986. Effects of frequent interactions with humans on growing pigs. Appl. Anim. Behav. Sci. 16, 269–273.

Guide for the Care and Use of Agriculture Animals in Research and Teaching (GUCAA), third edition, 2010. Environmental enrichment. Federation of Animal Science Societies. Champaign, IL.

Haskell, M.J., Hutson, G.D., 1996. The pre-farrowing behaviour of sows with access to straw and space for locomotion. Appl. Anim. Behav. Sci. 49, 375–387.

Herskin, M.S., Jensen, K.H., 2000. Effects of different degrees of social isolation on the behaviour of weaned piglets kept for experimental purposes. Anim. Welfare 9, 237–249.

Home Office, 2011 Statistics of Scientific Procedures on Living Animals Great Britain 2010. The Stationery Office, London. Publication HC 1263.

Hughes, B.O., 1976. Preference decisions of domestic hens for wire or litter floors. Appl. Anim. Behav. Sci. 2, 155–165.

Hutson, G.D., Dickenson, L.G., Wilkinson, J.L., Luxford, B.G., 1993. The response of sows to novel visual, olfactory, and tactile stimuli. Appl. Anim. Behav. Sci. 35, 255–266.

Ishiwata, T., Kilgour, R., Uetake, K., Eguchi, Y., Tanaka, T., 2007. Choice of attractive conditions by beef cattle in Y-maze just after release from restraint. J. Anim. Sci. 85, 1080–1085.

Kirkden, R.D., Pajor, E.A., 2006. Using preference, motivation and aversion tests to ask scientific questions about animals' feelings. Appl. Anim. Behav. Sci. 100, 29–47.

Kikusui, T., Winslow, J.T., Mori, Y., 2006. Social buffering: relief from stress and anxiety. Proc. Proc. Roy. Soc. Lond. B: Bio. 361, 2215–2228.
Kristensen, H.H., Jones, R.B., Schofield, C., White, R.P., Wathes, C.M., 2001. The use of olfactory and other cues for social recognition by juvenile pigs. Appl. Anim. Behav. Sci. 72, 321–333.
Kyriazakis, I., Whittemore, C.T., 2006. Whittemore's Science and Practice of Pig Production. Blackwell Publishing, Oxford, UK.
Liddell, B.J., Brown, K.J., Kemp, A.H., Barton, M.J., Das, P., Peduto, A., Gordon, E., Williams, L.M., 2005. A direct brainstem–amygdala–cortical 'alarm' system for subliminal signals of fear. Neuroimage 24, 235–243.
Lyons, C.A.P., Bruce, M.J., Fowler, V.R., English, P.R., 1995. A comparison of productivity and welfare of growing pigs in four intensive systems. Livest. Prod. Sci. 43, 265–274.
Mendl, M., Held, S., 2001. Living in groups: An evolutionary perspective. In: Keeling, L., Gonyou, H. (Eds.), Social Behaviour in Farm Animals. CABI Publishing, Wallingford, UK.
Mills, D.S., Davenport, K., 2002. The use of a mirror for the control of stereotypic weaving behaviour in the stabled horse. Anim. Sci. 74, 95–101.
Montevechhi, W.A., Noel, P.E., 1978. Temporal effects of mirror-image stimulation on pecking and peeping in isolate, pair- and group-reared domestic chicks. Behav. Biol. 23, 531–535.
Newberry, R.C., 1995. Environmental enrichment: increasing the biological relevance of captive environments. Appl. Anim. Behav. Sci. 44, 229–243.
O'Connell, N.E., Beattie, V.E., 1999. Influence of environmental enrichment on aggressive behaviour and dominance relationship in growing pigs. Anim. Wel. 8, 269–279.
Olson, H., Betton, G., Robinson, D., Thomas, K., Monro, A., Kolaja, G., Lilly, P., Sanders, J., Sipes, G., Bracken, W., Dorato, M., Van Deun, K., Smith, P., Burger, B., Heller, A., 2000. Concordance of the toxicity of pharmaceuticals in humans and animals. Regul. Toxicol. Pharmacol. 32, 56–67.
Parrott, R.F., Houpt, K.A., Mission, B.H., 1988. Modification of the responses of sheep to isolation stress by the use of mirror panels. Appl. Anim. Behav. Sci. 19, 331–338.
Piller, C.A., Stookey, J.M., Watts, J.M., 1999. Effects of mirror-image exposure on heart rate and movement of isolated heifers. Appl. Anim. Behav. Sci. 63, 93–102.
Rault, J.-L., 2011. Friends with benefits: social support and its relevance for farm animal welfare. Appl. Anim. Behav. Sci. 136, 1–14.
Richter, S.H., Garner, J.P., Würbel, H., 2009. Environmental standardization: cure or cause of poor reproducibility in animal experiments? Nat. Methods 6, 257–261.
Ruis, M.A.W., te Brake, J.H.A., Engel, B., Buist, W.G., Blokhuis, H.J., Koolhaas, J.M., 2001. Adaptation to social isolation: acute and long-term stress responses of growing gilts with different coping characteristics. Physiol. Behav. 73, 541–551.
Rushen, J., Taylor, A.A., De Passillé, A.M., 1999. Domestic animals' fear of humans and its effect on their welfare. Appl. Anim. Behav. Sci. 65, 285–303.
Schook, L., Beattie, C., Beever, J., Donovan, S., Jamison, R., Zuckermann, F., Niemi, S., Rothschild, M., Rutherford, M., Smith, D., 2005. Swine in biomedical research: creating the building blocks of animal models. Anim. Biotechnol. 16, 183–190.
Seyfarth, R.M., Cheney, D.L., 2003. Meaning and emotion in animal vocalizations. Ann. N.Y. Acad. Sci. 1000, 32–55.
Spani, D., Arras, M., Konig, B., Rulicke, T., 2003. Higher heart rate of laboratory mice housed individually vs in pairs. Lab. Anim. 37, 54–62.
Stolba, A., Wood-Gush, D.G.M., 1989. The behaviour of pigs in a semi-natural environment. Anim. Prod. 48, 419–425.
Tuchscherer, M., Kanitz, E., Puppe, B., Tuchscherer, A., Stabenow, B., 2004. Effects of postnatal social isolation on hormonal and immune responses of pigs to an acute endotoxin challenge. Physiol. Behav. 82, 503–511.
Tuchscherer, M., Kanitz, E., Puppe, B., Tuchscherer, A., 2006. Early social isolation alters behavioral and physiological responses to an endotoxin challenge in piglets. Horm. Behav. 50, 753–761.
Tuyttens, F.A.M., Wouters, F., Struelens, E., Sonck, B., Duchateau, L., 2008. Synthetic lying mats may improve lying comfort of gestating sows. Appl. Anim. Behav. Sci. 114, 76–85.
Van de Weerd, H.A., Day, J.E.L., 2009. A review of environmental enrichment for pigs housed in intensive housing systems. Appl. Anim. Behav. Sci. 116, 1–20.
Van de Weerd, H.A., Docking, C.M., Day, J.E.L., Avery, P.J., Edwards, S.A., 2003. A systematic approach towards developing environmental enrichment for pigs. Appl. Anim. Behav. Sci. 84, 101–118.
Ward, P., Zahavi, A., 1973. The importance of certain assemblages of birds as "information-centres" for food-finding. IBIS 115, 517–534.
Webster, J., Bollen, P.J.A., Grimm, H., Jennings, M., 2010. Ethical implications of using the minipig in regulatory toxicology studies. J. Pharmacol. Toxicol. Methods 62, 160–166.
Wechsler, B., 1995. Coping and coping strategies: a behavioural review. Appl. Anim. Behav. Sci. 43, 123–134.
Weiss, J.M., 1968. Effects of coping responses on stress. J. Comp. Physiol. Psychol. 65, 251–260.
Zonderland, J.J., Cornelissen, L., Wolthuis-Fillerup, M., Spoolder, H.A.M., 2008. Visual acuity of pigs at different light intensities. Appl. Anim. Behav. Sci. 111, 28–37.
Zotte, A.D., Princz, Z., Matics, Z., Gerencse, Z., Metzger, S., Szendro, Z., 2009. Rabbit preference for cages and pens with or without mirrors. Appl. Anim. Behav. Sci. 116, 273–278.